GERT

General Employee Radiological Training at Berkeley Lab

BERKELEY LAB

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CONTENTS

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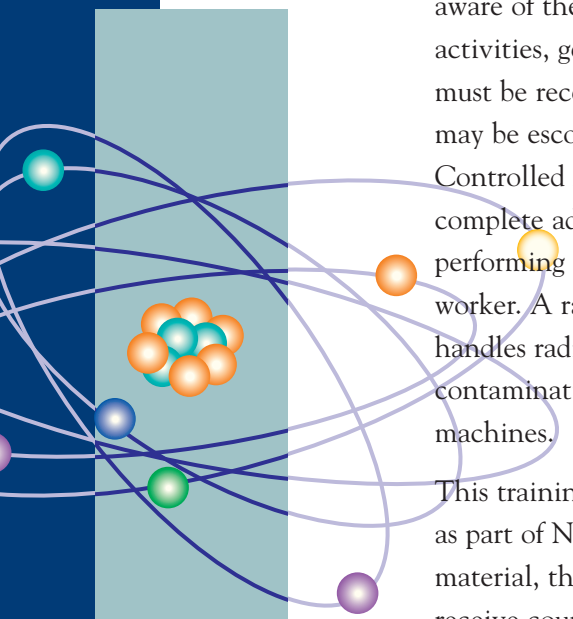

A variety of radioactive materials and radiation-producing machines, such as X-ray machines, electron beam devices, and accelerators, are used in research at the Berkeley Lab. All of the Berkeley Lab radiological work is located within posted Controlled Areas for Radiation Protection (Controlled Areas). Department of Energy (DOE) regulations require that, to ensure employees and guests are aware of the potential hazards associated with these activities, general employee radiation training (GERT) must be received prior to access into these areas. Visitors may be escorted by a trained GERT employee while in Controlled Areas. It is also required that an employee complete additional radiological worker training before performing unescorted work assignments as a radiological worker. A radiological worker is defined as someone who handles radioactive materials, works in a radiation or contamination area, or operates radiation-producing machines.

This training provides initial GERT instruction to all staff as part of New Employee Orientation. After reading this material, the employee will need to pass a short quiz to receive course credit for EHS0470. Individuals who have completed GERT may escort untrained visitors into Controlled Areas with which they are familiar. The escort is responsible for ensuring that the untrained visitor complies with all applicable radiation safety requirements. This training provides general information about radiation, its risks, the controls Berkeley Lab implements to ensure the safety of workers and the environment, and each individual's rights and responsibilities. For specific information about your work area contact your Supervisor/ Work Lead, Division Safety Coordinator, or the Environment, Health & Safety Division.

What Is Radiation and Where Does It Come From?

The type of radiation referred to in this training is ionizing radiation, invisible particles or waves of energy emitted from radioactive atoms or radiation-producing machines. Non-ionizing radiation (e.g., laser light and microwave radiation) presents very different hazards and is controlled through the Non-ionizing Radiation program (call 510-495-2544 for additional information). The common types of ionizing radiation are alpha, beta, neutron, X ray, and gamma radiation. Some radioactive atoms (e.g., uranium-238 and thorium-232) are natural; others (e.g., plutonium-239 and iodine-131) are man-made. If the energy from the radiation is deposited in a person, he or she receives a radiation dose. Radiation doses are measured in millirems (mrem) or rems. One thousand millirems equal one rem (1,000 mrem = 1 rem). The international unit for radiation dose, sievert (Sv) or millisievert (mSv), may also be used.

Background radiation is radiation from our natural environment. Everyone is exposed to some amount of background radiation. This exposure primarily comes from cosmic rays, radioactive material in the earth (such as uranium-238), ingestion of naturally occurring radionuclides in food (such as potassium-40), and inhalation of radon gas progeny (in particular the short-lived alpha emitters). In the United States, the average background radiation dose is 300 mrem/yr (3 mSv/yr) from naturally occurring sources. The Bay Area has a slightly lower average dose of approximately 200 mrem/yr (2 mSv/yr) from naturally occurring sources, because radon levels are lower here.

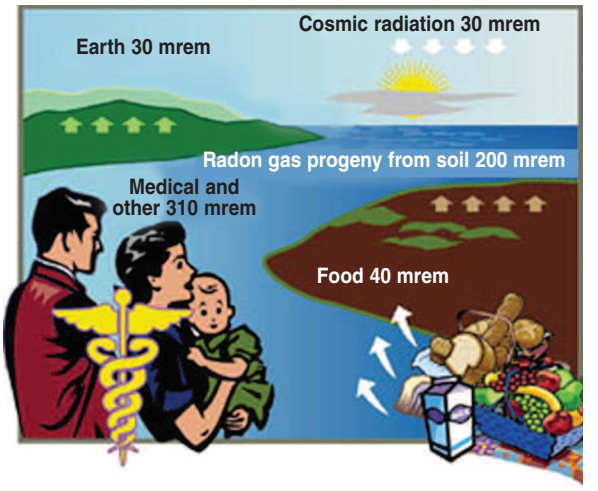

Figure 1. Annual Radiation Doses in the United States from Natural and Manufactured Radiation Sources.[1]

Manufactured sources contribute an additional background radiation dose of approximately 310 mrem/yr (3.1 mSv/yr). Of this amount, approximately 300 mrem (3.0 mSv) is from medical procedures (e.g., X-rays, CT scans and diagnostic tests). Consumer products such as fertilizer, lantern mantles, smoke detectors, and uranium-glazed pottery contribute roughly 5 mrem/yr (0.05 mSv/yr). Fallout radiation that is present in our environment contributes less than 1 mrem/yr (0.01 mSv/yr). Figure 1 shows typical annual radiation doses in the United States.

Occupational Dose Limits

In the course of their work, some individuals may receive exposure above background levels. The DOE carefully monitors these levels at all of its facilities and sets limits for acceptable doses. The DOE annual dose limits for occupational radiation exposure at Berkeley Lab are shown in Table 1. These limits are in addition to the average background dose of 200 mrem/yr (2 mSv/yr) and do not include exposures from medical sources.

Table 1. **Berkeley Lab Annual Occupational Dose Limits.**

Group	Dose limit (mrem/yr)
LBNL radiological worker	5000 (50 mSv)
Embryo-fetus of a radiological worker	500 (5 mSv)**
Minors, members of the public, and general employees*	100 (1 mSv)

* The internal guideline for general employees is more restrictive than the DOE limit.
**500 mrem/gestation

Berkeley Lab strives to keep radiation doses to workers, the public, and the environment as low as reasonably achievable (ALARA) below the annual dose limits set by the DOE. As Figure 2 shows, Berkeley Lab has been very successful in keeping radiation exposures ALARA.

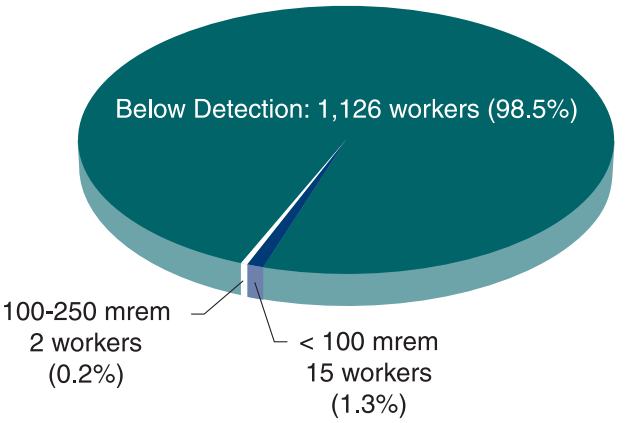

Figure 2. Occupational Radiation Doses Received by Berkeley Lab Personnel in 2007.

In 2007, 99 percent of all personnel monitored received no occupational radiation exposure. This exposure distribution is typical at Berkeley Lab. For a perspective, Table 2 shows the average doses received by workers in other occupations.

Table 2. **Average Annual Occupational Radiation.**

Occupation	Approximate Exposure (mrem/yr)
Airline flight crew member	500 (5 mSv)
Nuclear power plant worker	310 (3.1 mSv)
Medical personnel	70 (0.7 mSv)

Risks Associated with Radiation Exposure

The primary risk from occupational radiation exposure is an increased risk of cancer. The amount of risk depends on the amount of radiation dose received, the time over which the dose is received, and the body parts exposed. Scientists postulate that low-level radiation exposure may increase one's risk of cancer, however medical studies have not demonstrated adverse health effects in individuals exposed to small chronic radiation doses (i.e., up to 10,000 mrem [0.1 Sv] above background).

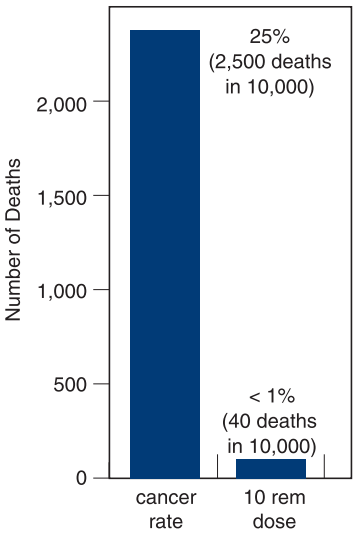

Figure 3. Estimated Cancer Risks to a population of 10,000.

The increased risk of cancer from occupational radiation exposure is small when compared to the normal cancer rate in today's society. The current lifetime risk of dying from any type of cancer in the United States is approximately 25 percent (see Figure 3). If a person were to receive, over a lifetime, a cumulative radiation dose of 10,000 mrem (0.1 Sv) to the entire body (above background), his or her estimated risk of dying from cancer would increase to 25.4 percent.

Protecting the Embryo-Fetus

Although heritable effects from radiation exposure have not been observed in humans, the embryo-fetus is known to be more sensitive to radiation than adults. Therefore, radiological workers who are pregnant, suspect they are pregnant, or are planning a pregnancy may want to notify the Laboratory's Health Services Department (510-486-6266) as early as possible. Health Services will arrange to have the workplace evaluated for potential hazards to the embryo-fetus. (If desired, this evaluation can be conducted confidentially.) Workplace or task modification is typically not necessary because 99 percent of all Berkeley Lab personnel who are monitored receive only background levels of radiation. The Berkeley Lab cannot give this special consideration until the pregnancy is declared.

For additional information on the effects of radiation and other toxic agents on human reproduction, see Workplace Hazards to Reproductive Health. This pamphlet is available from Health Services.

Monitoring Radiation Exposure

To ensure that exposures are ALARA, Berkeley Lab monitors many of its workers to determine the actual exposures received. Most of these individuals are monitored for external or penetrating radiation and wear dosimeters to measure their exposures.

A dosimeter is a device that is worn like a name tag and measures the radiation dose a person receives from external sources. Currently, about one-fourth of all Berkeley Lab staff routinely wear dosimeters. Dosimeters are exchanged and the radiation doses are measured monthly or quarterly by the Dosimetry Lab. Your supervisor will be able tell you whether or not you should be in this program. Even if you are not required to wear a dosimeter in your work area, one can be made available to you upon request. If you would like a dosimeter, please call the Dosimetry Lab at 510-486-7497 to make arrangements. The type of dosimeter routinely used at Berkeley Lab is an optically stimulated luminescence dosimeter (OSL) (see Figure 4). OSLs contain crystals that absorb energy when exposed to ionizing radiation. They release that energy in the form of blue light when exposed to green light in the dosimeter reader. The amount of blue light released from the dosimeter is proportional to the radiation dose received. It is useful for a broad range of the penetrating radiation fields found at the Berkeley Lab, including beta, gamma, and X rays. Workers who need to be monitored for neutron radiation exposure are issued an additional CR-39 track-etch dosimeter.

Figure 4. Optically Stimulated Luminescence Dosimeter

All Berkeley Lab workers who wear dosimeters are provided with an annual exposure summary, even if they received no radiation exposure that year. Additionally:

- If a worker receives a radiation dose at any point during the year, a radiation dose report will be sent to the worker at the end of the exchange cycle.
- A worker can request an exposure report at termination of employment.
- Anytime LBNL must report an exposure to DOE, the individual will also receive the report.
- Anyone who has worn a dosimeter at the Berkeley Lab may obtain a copy of his/her dose report upon request from the Dosimetry Lab or via the web at https://ehswprod.lbl.gov/Rems/Login.asp.

A few radiological workers are also monitored for internal doses. A person may receive an internal dose through the ingestion or inhalation of radioactive materials. This monitoring typically focuses on a few individuals who routinely handle dispersible radioactive materials. Dose levels are assessed by measuring radioactivity excreted by

the body or by measuring the radiation emitted from inside the body. Positive internal doses are reported to the individual and are included in his or her personnel dosimetry record, in the same manner as external doses recorded by the OSLs.

Radiation Safety Controls

Before any radiological work is allowed, it must be thoroughly reviewed and approved by the Radiation Protection Group. Authorizations that describe the work, hazards, controls, and evaluations are formally implemented to ensure that all work is performed safely. Each individual's roles and responsibilities are specifically assigned during this process. For more information, see Chapter 21 of PUB-3000 (Berkeley Lab Health and Safety Manual). The two basic types of radiation safety controls that are used at Berkeley Lab are engineered and administrative. Engineered controls—such as shielding, interlocks, ventilation, alarms, warning signals, and material containment—are the primary means of control. Administrative controls—such as signs, procedures, dosimetry, and training—supplement the engineered controls. All work is planned with the objective of keeping exposures ALARA. In particular, the following techniques are used by all radiological workers:

- Minimize the time you are exposed to radiation sources.
- Maximize your distance from radiation sources. The radiation level decreases significantly as you move away from the source.
- Employ appropriate shielding between you and the radiation source. For some sources, a plastic barrier is appropriate; for others, a lead shield is used.

Radiation Signs

One of the most important components of the Berkeley Lab safety program is the posting of warning and notice signs in areas that are controlled for purposes of radiation safety. These signs alert personnel to the potential hazards from radiation in these areas.

There are two types of hazardous areas at Berkeley Lab. Controlled Areas are posted with blue-and-white notice signs. These areas serve as buffer areas for the second area, which contains the radiological material or the radiation-producing machine. Figure 5 is an example of a Controlled Area sign. Individuals who have completed GERT training are authorized to enter Controlled Areas without escort.

The area within the Controlled Area where the radiological material is handled or where a radiation field exists is posted with yellow-and-black or yellow-and-magenta signs with the radiation trefoil symbol. Individuals must check with personnel authorized to work in those areas prior to entry.

Figure 5. Controlled Area Sign.

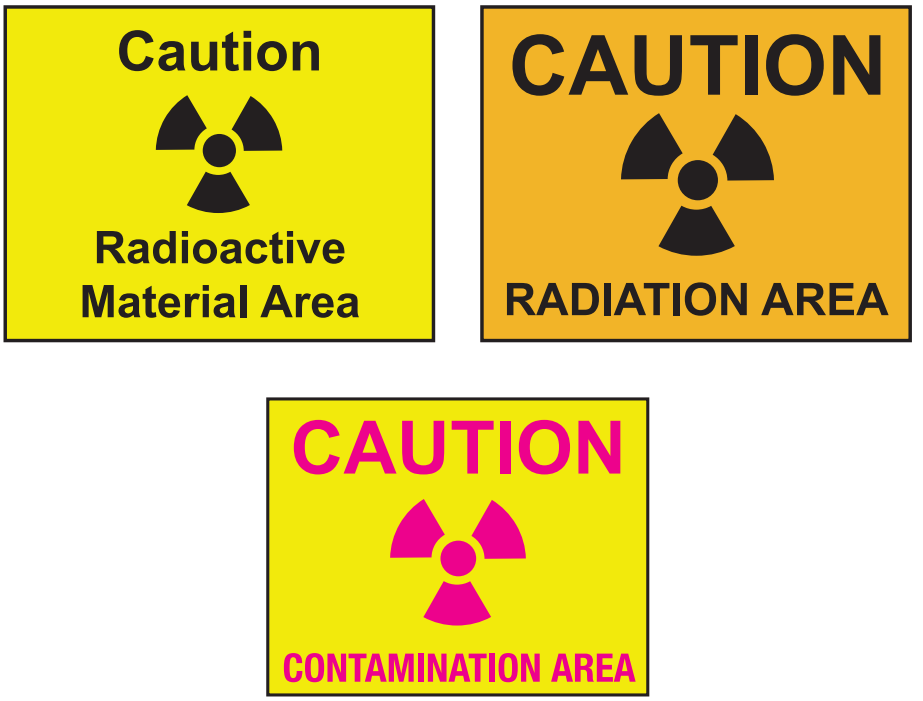

Figure 6. Radiation Signs.

Additional training is required. Radiological worker training is required prior to handling radioactive material or potentially contaminated surfaces, or working in a radiation field. Figure 6 shows examples of radiation signs.

Radioactive Material/Radiation-Producing Machines

All procurement, handling, transfer, and use of radioactive materials must be authorized by an approved authorization from the Radiation Protection Group, which details work activities, locations, and authorized personnel. Chapter 21 of PUB-3000 provides detailed guidelines for working with radioactive materials. All transportation (shipping or receipt) of radioactive material or equipment must be performed by the Radiation Protection Group at 510-486-6228.

All radioactive material must be kept within Controlled Areas (posted with blue-and-white notice signs) and, in most cases, within a posted Radioactive Material Area (posted with a yellow-and-black or yellow-and-magenta sign). All employees must be familiar with these signs. If you notice an item with the trefoil symbol located outside of a Controlled Area, notify the Radiation Protection Group (510-486-7277) immediately.

Employee/Visitor Responsibilities

You are responsible for doing your job safely. You should thoroughly understand all hazards and controls associated with your work. If you have safety concerns, discuss them with the responsible individual, your supervisor, or EH&S Division personnel before beginning the work.

You must attend additional radiation worker training before beginning any job that involves handling radioactive materials or operating radiation-producing machines. Also, this work must be formally authorized by the EH&S Division (Chapter 21, PUB-3000).

If you are a supervisor or manager, you are responsible for providing a safe work environment and for ensuring that the requirements in PUB-3000 are implemented for those workers who are under your supervision.

If you are a visitor, you are responsible for obeying all posted signs, attending required training, and reporting any unsafe conditions to your hosts.

Bibliography and References

1. National Council on Radiation Protection and Measurements (NCRP), *Ionizing Radiation Exposure of the Population of the United States, Report 160*, Bethesda, MD, 2006.
2. U.S. Department of Energy "Occupational Radiation Protection, Final Rule," *Code of Federal Regulations, Title 10, Part 835*, January 1, 2008.
3. The National Research Council Committee on the Biological Effects of Ionizing Radiation, *Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR V*, Washington, D.C., 1990.
4. Health Physics Society, *Radiation Risk in Perspective, Position Statement*, 2004.
5. U.S. Nuclear Regulatory Commission, *Instruction Concerning Risks from Occupational Radiation Exposure, Regulatory Guide 8.29, Rev. 1*, NRC, Washington, D.C., February 1996.
6. American Cancer Society, *Cancer Facts and Figures 2007*, Atlanta, GA, 2007.
7. International Council on Radiation Protection (ICRP), *Recommendations of the International Commission on Radiological Protection, Publication 60*, Oxford, England, 1990.

Other Sources of Information

LBNL Health and Safety Manual, PUB-3000
(http://www.lbl.gov/ehs/pub3000/)

EH&S Division Web Site
(http://www.lbl.gov/ehs/)

Radiation Protection
510-486-7652
510-486-7277 (24 hour urgent assistance)

Dosimetry Lab
510-486-7497

Key Facts

Controlled Area Sign. Unescorted access to this area requires GERT.

Radioactive Material Area Sign. No entry without further training.

Additional copies of this booklet may obtained by contacting:

Radiation Protection
510-486-7652

Dosimetry Lab
510-486-7497

EH&S Training Program
510-495-2228

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